R E S U L T S O F A N A C C I D E N T A L E X P L O S I O N I N A P R O P E L L A N T P R O C E S S B U I L D I N G

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A B S T R A C T

In January 1990, an accidental explosion occurred in a propellant process building in one of Israel Military Industries' plants.

The building collapsed and debris was found beyond the surrounding barricades.

The paper describes the building and its vicinity before and after the explosion.

Simple calculations according to the manual "Structures to resist the effects of accidental explosions",were made in order to determine the amount of T.N.T equivalent that would have caused the same effects to the structure and its surrounding.

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I N T R O D U C T I O N

On January,2nd 1990 , at 3:00 P.M. , an explosion occurred in a building containing about 1500 Kg. of propellant in process, in one of I.M.I's plants.
Fortunately, no one was hurt and only minor damage occurred to adjacent structures

The building collapsed, and debris was thrown beyond the surrounding barricades, while most of the structural elements were found within the area enclosed by the barricades.

Since we knew the exact location of the center of the explosion, we made some simple calculations according to the manual "Structures to resist the effects of accidental explosions" (last edition) (1) ,in order to determine what amount of T.N.T equivalent would have caused the same effects to the structure and its surrounding.

This is in spite of the fact that no real detonation occurred.
We need this information for future consideration regarding that propellant material.

From now on, we shall assume that the material which exploded in this building was T.N.T .

THE BUILDING DESCRIPTION

The building (shown in pic. no' 1) was made of a reinforced concrete skeleton and the walls - of concrete blocks.
The building had two wings :
1) The production hall, measuring 12.1 x 9.6 x 8.0 m.
2) The utility room, measuring 7.0 x 7.1 x 5.0 m.

The northern wall - partly attached to the utility room, was made of reinforced concrete beams and columns, filled with concrete blocks.
The western wall - (shown in fig. no' 1) was made of reinforced concrete beams and columns filled with concrete blocks.

The eastern wall - (shown in fig. no' 2) was made of reinforced concrete beams and columns filled with concrete blocks. A double winged steel door measuring 4.0 x 6.5 m. was made of R.H.S steel profiles, covered on both sides with 2 mm. steel plates.
The door was encased with a reinforced concrete frame supporting the main concrete beam on the roof.
The wall above the top level of the door to the ceiling, was made of reinforced concrete.

The southern wall - (shown in fig. no' 3) This was a light- weight wall, about 1/4 of its area was made of concrete blocks and 3/4 was made of reinforced concrete beams and columns filled with thin plastic panes.
A steel bridge connected an escape doorway with the nearby barricade.

The roof - was a reinforced concrete solid slab partly supported by a huge concrete beam.This beam supported a monorail in the production hall as well.
The roof of the utility room was a two-way ribbed floor slab.

The exact point of the center of the explosion is seen in the longitudinal section of the building (fig. no' 4).

THE SURROUNDING AREA

Fig. no' 5 is a map of the area. The two nearby buildings to the north-east (B) and to the south-east (C) resemble the damaged building (A). Those were surrounded by barricades and suffered only minor damage, especially the light weight walls and the glass windows.

115 m. to the south, a one story office building (D) was slightly damaged. All the glass panes were shattered. Some wooden doors were torn from the hinges.

160 m. to the east, a reinforced concrete control building (E) suffered only minor damage while 3 out of 4 glass windows were shattered.

Other buildings in the area were not damaged at all except for a few plastic panes which were sucked out.

From several sources dealing with glass breakage due to explosions, we could estimate the amount of T.N.T equivalent to be between a 100 to 500 kg. and later on we shall limit our search to these values.

DAMAGE TO THE BUILDING

As a result of the explosion, the entire structure collapsed. All the reinforced concrete elements and most of the wall blocks ,however,were found within the surrounding barricades.

The reinforced concrete columns were torn out of the pile caps and were ruined. The beams and the columns were blown in the direction of the barricades.
The roof was heavily cracked, the huge concrete beam was broken and all the roof, as a unit, landed on the wreckage below.
There was debris found beyond the surrounding barricades.

From the northern wall , concrete blocks were thrown to a maximum distance of 50 m.
From the southern wall , concrete blocks were found 60 m. away from the building.
From the eastern wall , the two wings of the steel door were thrown. One wing landed on the road 102 m. away and the other wing was found 70 m. from the building on top of the barricade of the adjacent building.

The road leading to the building was covered with broken concrete blocks. The steel door of the utility room was found 30 m. from its frame.

At a distance of 10 m. , on the retaining wall of the barricade edge,there landed - as a unit - the reinforced concrete wall that was above the steel door.

The pictures no' 2 to 10,describe the damage to the structure.

THE CALCULATIONS

The reason for the simple calculations made, was to estimate the amount of T.N.T equivalent that, if detonated in the center of the explosion, might have caused the same effects to the structure.

This information is essential for future consideration of safety distances and hardened structures involved, dealing with this type of propellant materials.

From the way the debris was scattered it was obvious that it was thrown perpendicular to the walls. This implies that the explosion effect was the same as an explosion confined within a cubical structure.

In case of a partially confined explosion, the manual (1) distinguishes between two kinds of impulses acting on the walls. The first is induced by the shock wave which is amplified due to the reflections by the other surfaces of the confining structure.
The other impulse is created by the accumulation of gaseous products and is characterized by pressures whose magnitude is generally much less than those of the shock pressure, but with a significantly longer duration.
As we shall see later from the calculated initial velocity of the secondary fragments,gas pressure from a T.N.T explosion acting on the walls is irrelevant, since there were no walls left to enable gas pressure to develop.

For the calculations, we chose representative fragments.
From the maximum flight distance of the fragment and from other data regarding their mass and shape we were able to find their initial velocity.

The impulse,which caused the flight,was calculated by equating it to the momentum.

Based on the manual (1) for a confined explosion in a cubicle-type structure, we found the impulses acting on the walls for different values of T.N.T charge.

With that data, we easily found out by interpolation the amount of T.N.T that if detonated in the known center of explosion, would have caused the fragment to reach the same maximum distances.

To arrang such a table, we needed to substitute for each different wall the T.N.T quantity versus the impulses it caused.

Since the charts in the manual present data only for distinct values of the scaled distance, we followed the procedure below:

1) For the relevant logarithmic chart (according to the configuration and geometry) we marked the corresponding value of the L/Ra for the wall we were dealing with.
2) We changed the axis of L/Ra so that it would represent the scaled distance axis Z.
3) We projected the intersections of the distinct value of Za with the value of L/Ra on the suitable Za values along the new Z axis.
4) We joined the projected points with a fitting curve.
5) We drew, by the same method, curves for different values of L/H, 1/L, h/H.
6) For every curve we got, we prepared a table describing the changing explosive quantity W, the scaled distance, the scaled impulse obtained by multiplying the scaled unit impulse with $W^{1/3}$.
7) We interpolated between the different values obtained from the different curves and got the impulse values acting on the wall versus different values of T.N.T charge (between a 100 to 500kg. T.N.T equivalent in our case).

After obtaining this table, we calculated the initial velocity of representative secondary fragments and this according to the following steps:

1) We determined the maximum flight distance of the fragment.
2) We calculated the weight and the mass of the fragment.
3) Out of table 2-8 of the manual, we determined the drag coefficient Cd.
4) We calculated the non-dimensional distance.
5) Out of figure 2.252 of the manual we got the non-dimensional initial velocity and from it we obtained the initial velocity of the fragment.
6) By multiplying the mass with the initial velocity we got the initial momentum of the element we were dealing with.
7) By equating the impulse with the momentum we obtained the impulse that made the element fly, and out of the table we had made earlier, we obtained the T.N.T quantity that if exploded, would have created that impulse.

IMPULSES ON THE WALLS

The impulses acting on the walls versus varying values of T.N.T qauntities were calculated for the eastern and northern walls.
Because the center of the explosion was relatively close to the western wall, very high impulses are anticipated for points on that wall near the center of the explosion, and low impulses will act on far points.

Since the values obtained from the charts of the manual, are average values of the distributed impulses on the wall, we believe that the values representing the average impulse on the western wall will not give us a true picture regarding the secondary fragments' initial velocity, and therefore, we considered only the eastern and western walls.

The eastern wall - according to fig. 2.51 of (1) for side wall of a three wall cubicle with a roof, we reached the following parameters :

N = 3	1/L = 2.5/8.0 = 0.31
Ra = 9.6 m = 31.5 feet	L/Ra = 8.0/9.6 = 0.83
h/H = 6.1/9.6 = 0.64	L/H = 8.0/9.6 = 0.83

According to table 2-3 of (1) the illustrations for a scaled average unit impulse for the above parameters are as follows:

h/H	1/L	figure
0.5	0.25	2.136
0.5	0.5	2.137
0.75	0.25	2.139
0.75	0.5	2.140

Fig. 6 to fig. 9 represent the scaled unit impulse versus the scaled distance Z, and this for the value of L/Ra = 0.83
Tables 1 and 2 present the values of the unit reflected impulse obtained from these diagrams including the interpolated values for L/H = 0.83

Table no. 5 is a summarized table containing the interpolated values where the middle column presents the interpolated values for our case (the eastern wall).

The northern wall - Back wall of three wall cubicle with roof.

N = 4

1/L = 2.5/12.1 = 0.21

Ra = 6.1 m = 20 feet

L/H = 12.1/8.0 = 1.51

h/H = 2.5/8 = 0.31

L/Ra = 12.1/6.1 = 1.98

The illustrations in the manual for the above parameters are as follows:

h/H	1/H	figure
0.25	0.1	2.144
0.25	0.25	2.145
0.50	0.1	2.146
0.50	0.25	2.148

Fig. 10 to fig. 13 represent the scaled unit impulse versus the scaled distance Z, and this for the value of L/Ra = 1.98
Tables 3 and 4 present the values of the unit reflected impulse obtained from these diagrams including the interpolated values for L/H = 1.51
Table no. 6 is a summarized table containing the interpolated values where the middle column presents the interpolated values for our case (the northern wall).
Fig. no'14 is a summarized graph which describes the impulse on the northern and the eastern walls versus T.N.T charge.

STEEL DOOR IN THE EASTERN WALL

Each wing was constructed of R.H.S steel grid covered with 2 mm. steel plates on both faces. The space in between was filled with an insulation material and it weighed :

W = 846 kg. = 1863 lb.

The mass of that element was :

$$M = \frac{1863}{32.2 \times 12 \times 10^{-6}} = 4{,}821{,}428 \ \frac{\text{lb-msec}^2}{\text{in}}$$

One wing landed on the access road 102 m. away while the other one was found on top of the barricade of the adjacent building about 70 m. away.

Since we could not be sure about the true flight distance of that wing, without the interruption of the trees on the barricade and since the calculation procedures in the manual refer only to a maximum flight distance, we concidered only the 102 m. distance in our calculations.

According to table 2-8 of (1) the drag coefficient Cd for a long rectangular member face-on is :

$$Cd = 2.05$$

For such a huge fragment like the door wing, we believe that this maximum value represents our case.

The non-dimensional range is :

$$\frac{12 \ Po \ Cd \ Ad \ R}{M} = \frac{12 \times 0.115 \times 2.05 \times (78.7 \times 260) \times 102}{4{,}821{,}428 \qquad 0.3048} = 4.02$$

Where :

Ad = drag area of the object [in^2]

Po = air density $\left[\frac{\text{lb-msec}^2}{\text{in}^4} \right]$

R = range of the object flight [feet]

With this calculated term we entered fig. 2-252 and obtained the value:

$$\frac{12 \ Po \ Cd \ Ad \ Vo^2}{Mg} = 30$$

from which the initial velocity was calculated :

$$Vo = \left[\frac{30 \times 4{,}821{,}428 \times 32.2}{12 \times 0.115 \times 2.05 \times 78.7 \times 260} \right]^{\frac{1}{2}} = 283.6 \text{ feet/sec.}$$

By equating the impulse with the momentum :

$$I = M\,Vo$$

$$I = \frac{4,821,428 \times 283.6 \times 12}{1,000} = 16,408,284 \text{ lb-msec.}$$

and the unit impulse was obtained by dividing it by the door wing area:

$$i = \frac{16,408,284}{78.7 \times 260} = 802 \text{ psi-msec.}$$

Out of fig. 14 that we had made ,we see that this is the unit impulse created by an explosion of about 215 kg. T.N.T

CONCRETE BLOCKS FROM THE NORTHERN WALL

The blocks from the northern wall were thrown to a maximum distance of R = 50 m. = 164 feet. True, there were blocks scattered at shorter distances but since the manual relates only to a maximum range prediction, we chose the maximum range for our calculations.

The weight of a block including the mortar is :

$$W = 25 \text{ kg.} = 55 \text{ lb.}$$

The mass of the block is :

$$M = \frac{W}{g} = \frac{55}{32.2 \times 12 \times 10^{-6}} = 142,340 \frac{\text{lb-msec}^2}{\text{in}}$$

The presented area of a block is :

$$Ad = 124 \text{ in}^2$$

According to table 2-8 of the manual, the drag coefficient for a cube element, face-on is Cd = 1.05 and for an edge-on cube Cd = 0.8 .
We averaged those values and assumed :

$$Cd = 0.925$$

The non-dimensional range is :

$$\frac{12\ Po\ Cd\ Ad\ R}{M} = \frac{12 \times 0.115 \times 0.925 \times 124 \times 164}{142,340} = 0.18$$

Out of fig. 2-252 we get the non-dimensional velocity :

$$\frac{12\ Po\ Cd\ Ad\ Vo^2}{Mg} = 0.2$$

from which the initial velocity was calculated :

$$Vo = \left[\frac{0.2 \times 142{,}340 \times 32.2}{12 \times 0.115 \times 0.925 \times 124} \right]^{\frac{1}{2}} = 76.1 \ \text{feet/sec.}$$

$$i = \frac{142{,}340}{124} \times \frac{76.1 \times 12}{1{,}000} = 1048 \ \text{psi-msec}$$

Out of fig. 14 we see that this is the impulse created by an explosion of 255 kg. T.N.T .

CONCRETE WALL ABOVE THE STEEL DOOR

This huge reinforced concrete element above the top level of the steel door in the eastern wall, was found near the building, where the center of gravity was 10 m. away from the wall, and 6.7 m. below its initial position.

Because of the huge mass of this element, which assures low velocities, and since the distance of the flight was relatively short, we may ignore drag forces, and consider the motion as a free fall with initial velocity.

The fall duration was :

$$T = \left[\frac{2h}{g} \right]^{\frac{1}{2}} \qquad S = 10 \text{ m.}$$

$$S = Vo\ T \qquad h = 6.7 \text{ m.}$$

$$Vo = S \left[\frac{g}{2h} \right]^{\frac{1}{2}}$$

and by substituting the above values we obtained the initial velocity :

$$Vo = 10 \times \left[\frac{9.8}{2 \times 6.7} \right]^{\frac{1}{2}} = 8.55 \text{ m./sec.}$$

The weight of the element was :

$$W = 11 \text{ ton} = 24{,}200 \text{ lb.}$$

and the mass was :

$$M = \frac{24{,}200}{32.2 \times 12 \times 10} = 62{,}629{,}400 \frac{\text{lb-msec}^2}{\text{in}}$$

By equaiting the impulse with the momentum :

$$I = M\,Vo = 62{,}629{,}400 \times \frac{8.55 \times 39.37}{1000} = 21{,}086{,}490 \text{ lb-sec.}$$

and the unit impulse was :

$$i = \frac{21{,}086{,}490}{1.45 \times 9.6 \times 39.37^2} = 977 \text{ psi-msec.}$$

According to fig. 14 we can see that to create such an impulse on the eastern wall, we need to explode 280 kg. of T.N.T .

CONCLUSION AND RECOMMENDATION

I.M.I adopted the regulations of the D.O.D standards. (Ammunition and Explosives Safety Standards - DoD 6055.9-STD)
This accident proved that the separation distances that had been taken from the D.O.D quantity - distance tables were adequate.

The acceptor buildings suffered only minor damage due to overpressure and although some fragments were found beyond the donor buildings barricades, they didn't reach other buildings.

By calculating the fragments' initial velocity according to the manual, we were able to find the impulse which propelled those fragments, and from that data we found the T.N.T equivalent and we can see that the values we got for different fragments were reasonably accurate.

However, if the building is rebuilt, we have the following recommendations to minimize debris hazard in case of accident reoccurrence :

1) To add to the height of the existing barricades.
2) To reinforce the double winged door by attaching it to the concrete roof or the frame, with a spring like cable which will reduce the flight distance in case of another explosion.
3) To build the upper part of the walls with reinforced concrete rather than the regular blocks used in the original building.
4) The entire southern wall should be built of completely light weight materials instead of what existed in the past. This would give more relief to the pressure and would eliminate debris hazard in the southern direction.

BIOGRAPHY

(1) "STRUCTURE TO RESIST THE EFFECT OF ACCIDENTAL EXPLOSIONS."

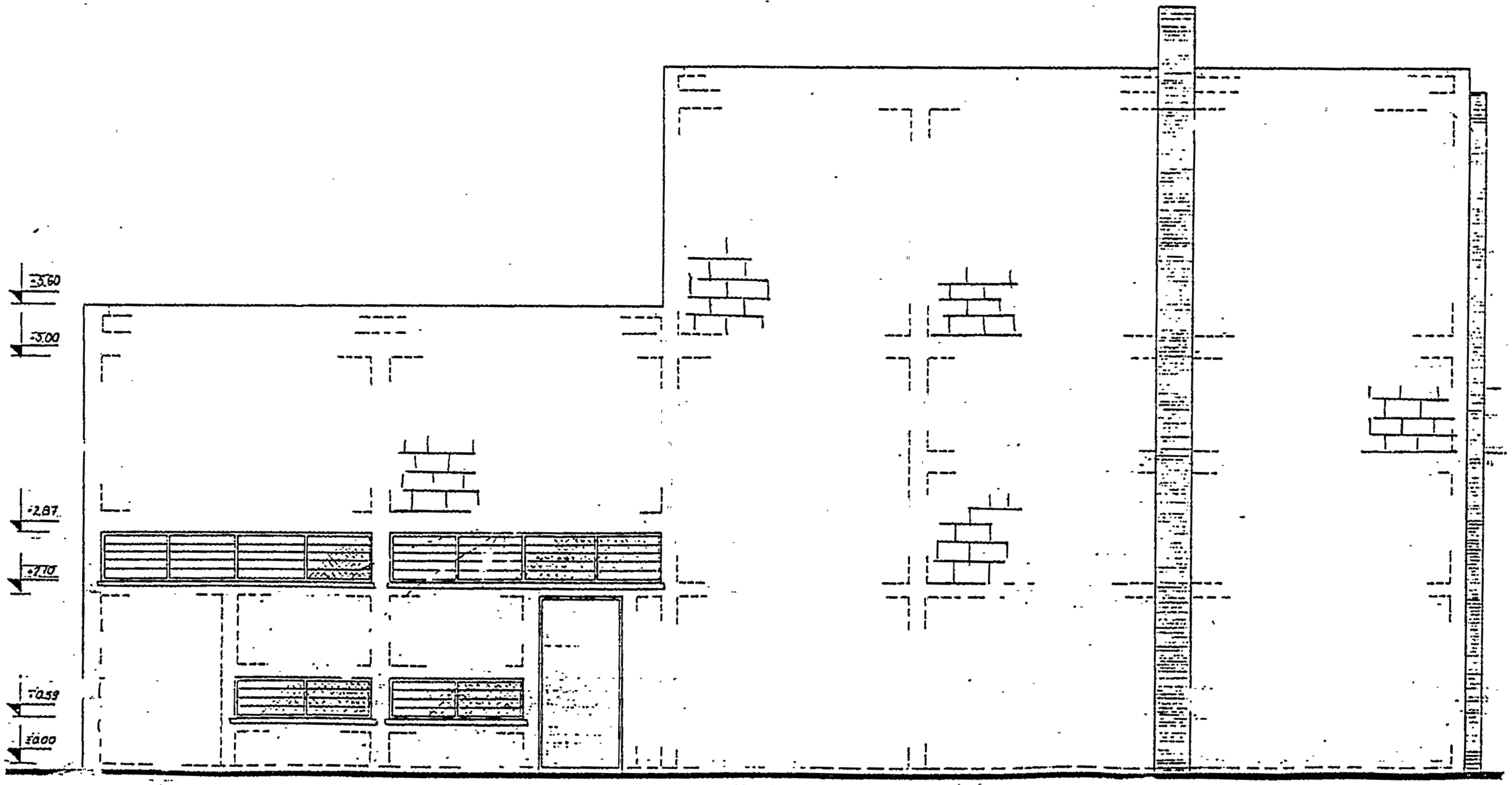


Fig. no' 1 - The western wall

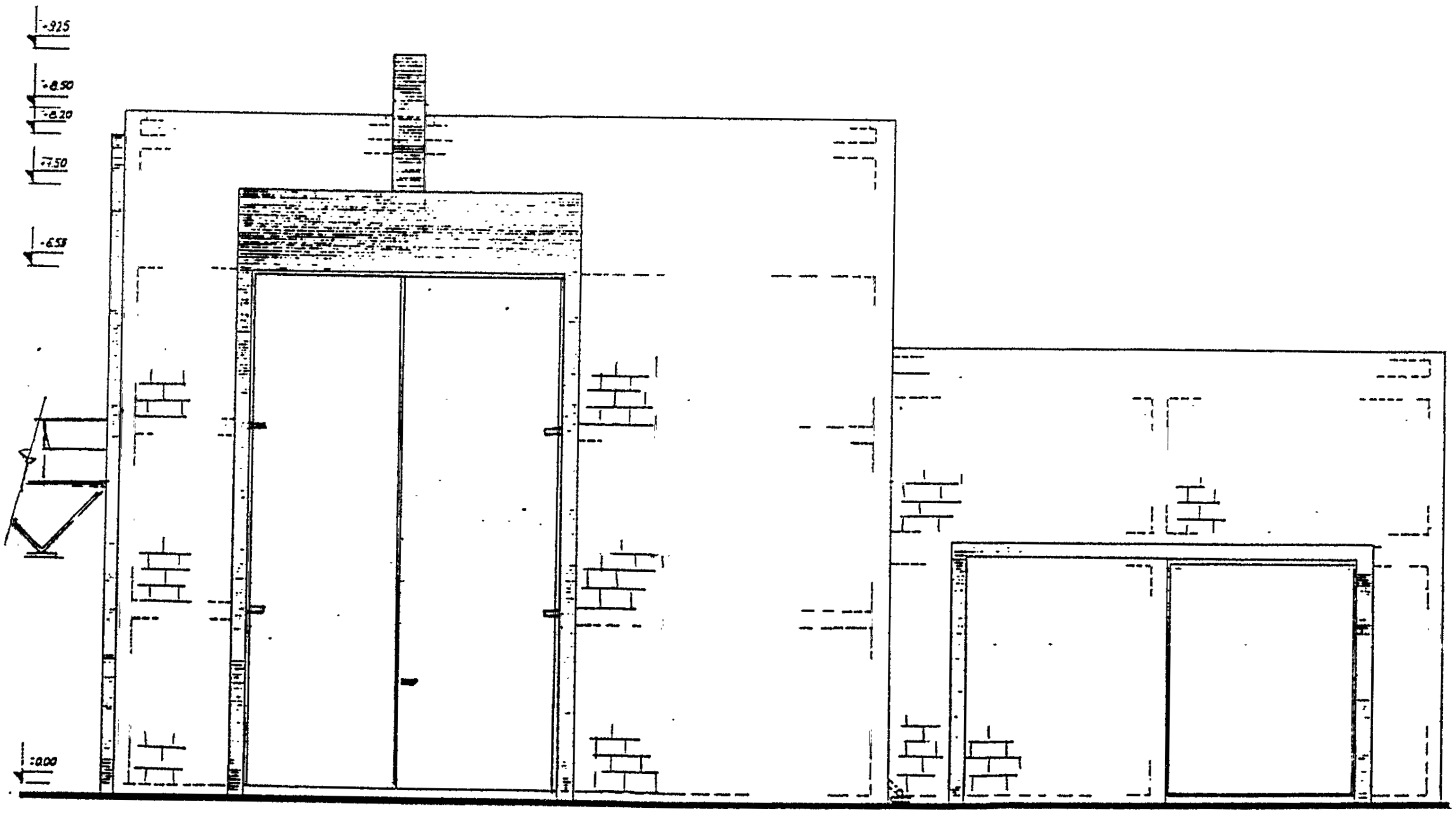


Fig. no' 2 - The eastern wall

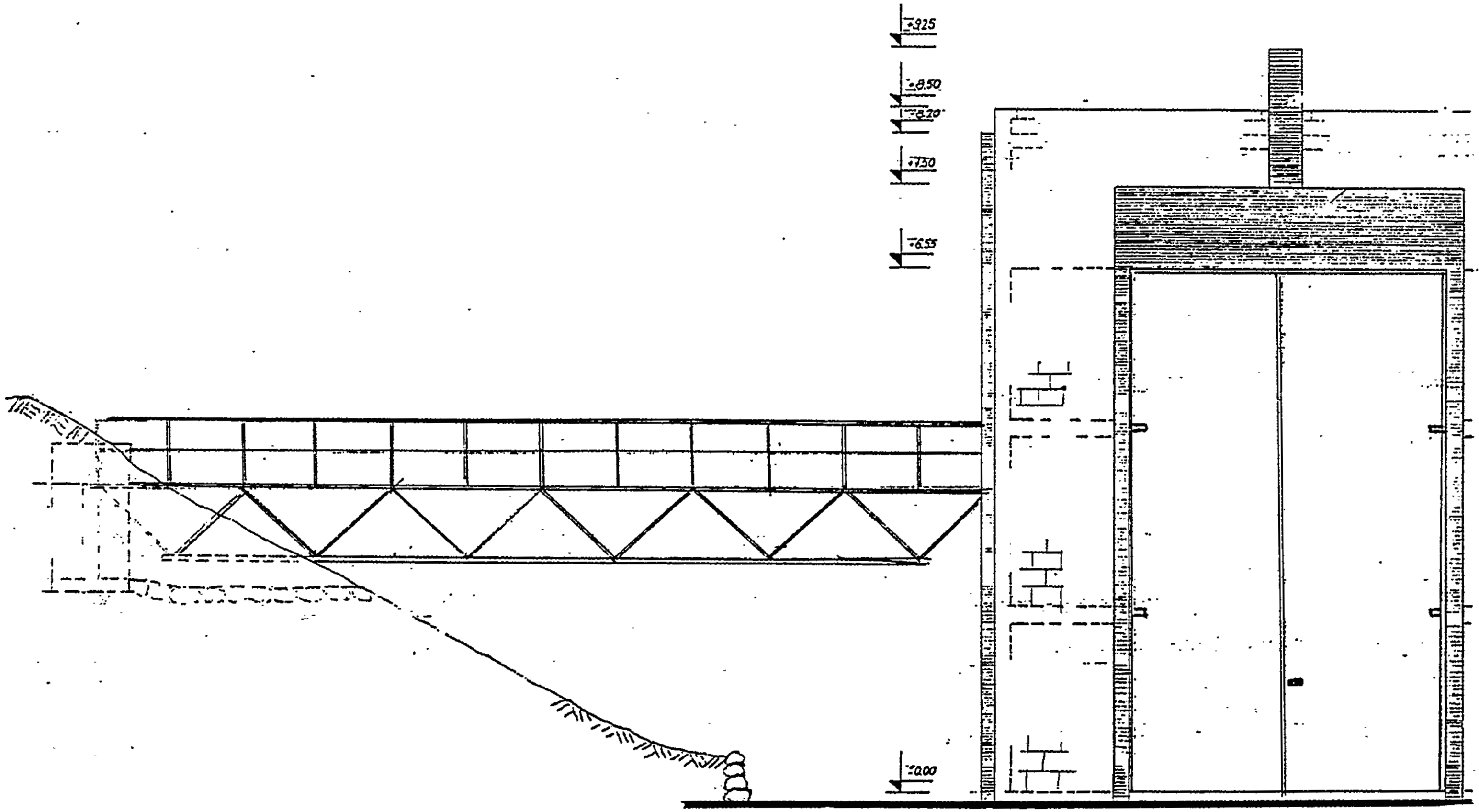


Fig. no' 2 - The eastern wall (continued)

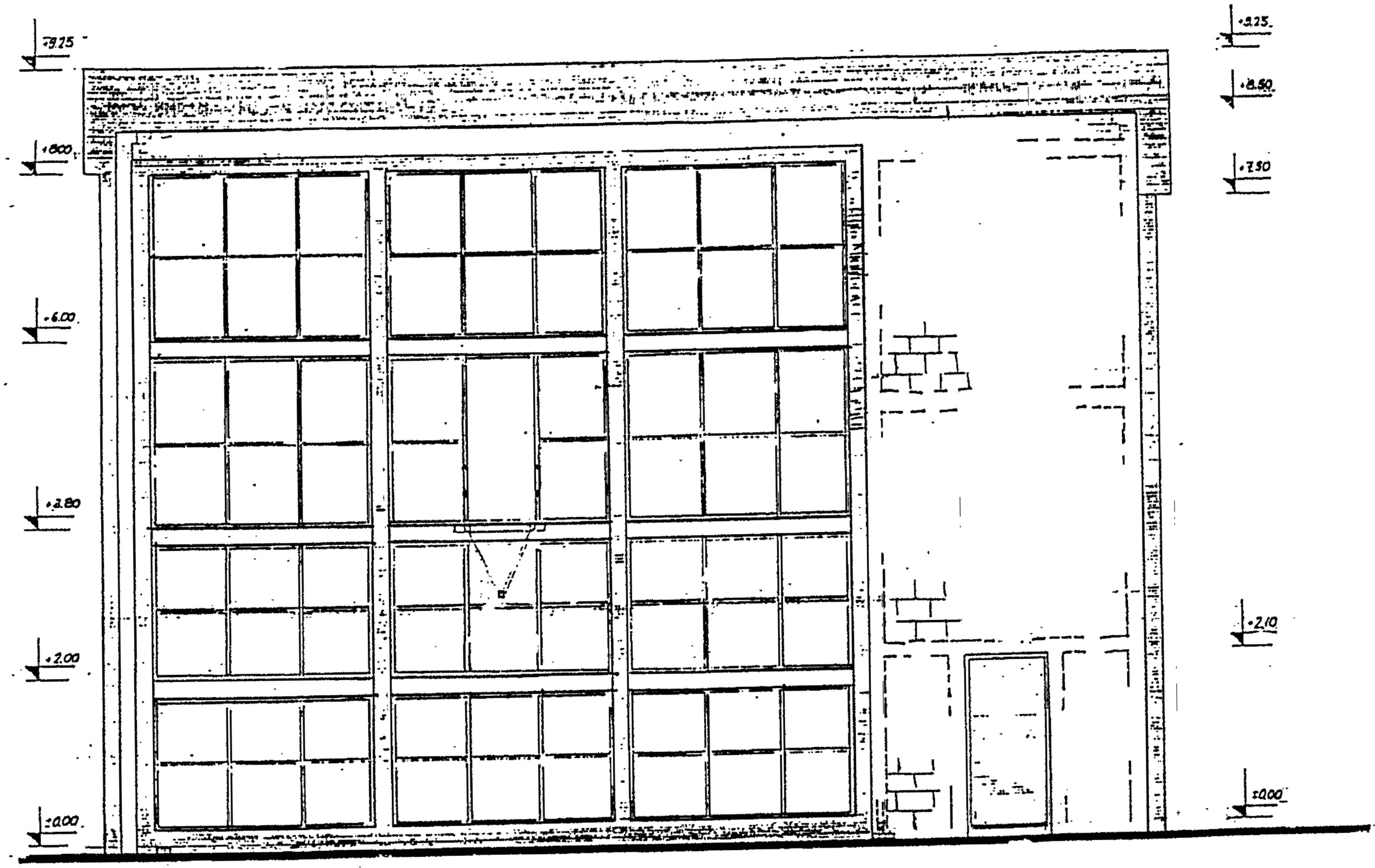


Fig. no' 3 - The southern wall (The light weight wall)

1745

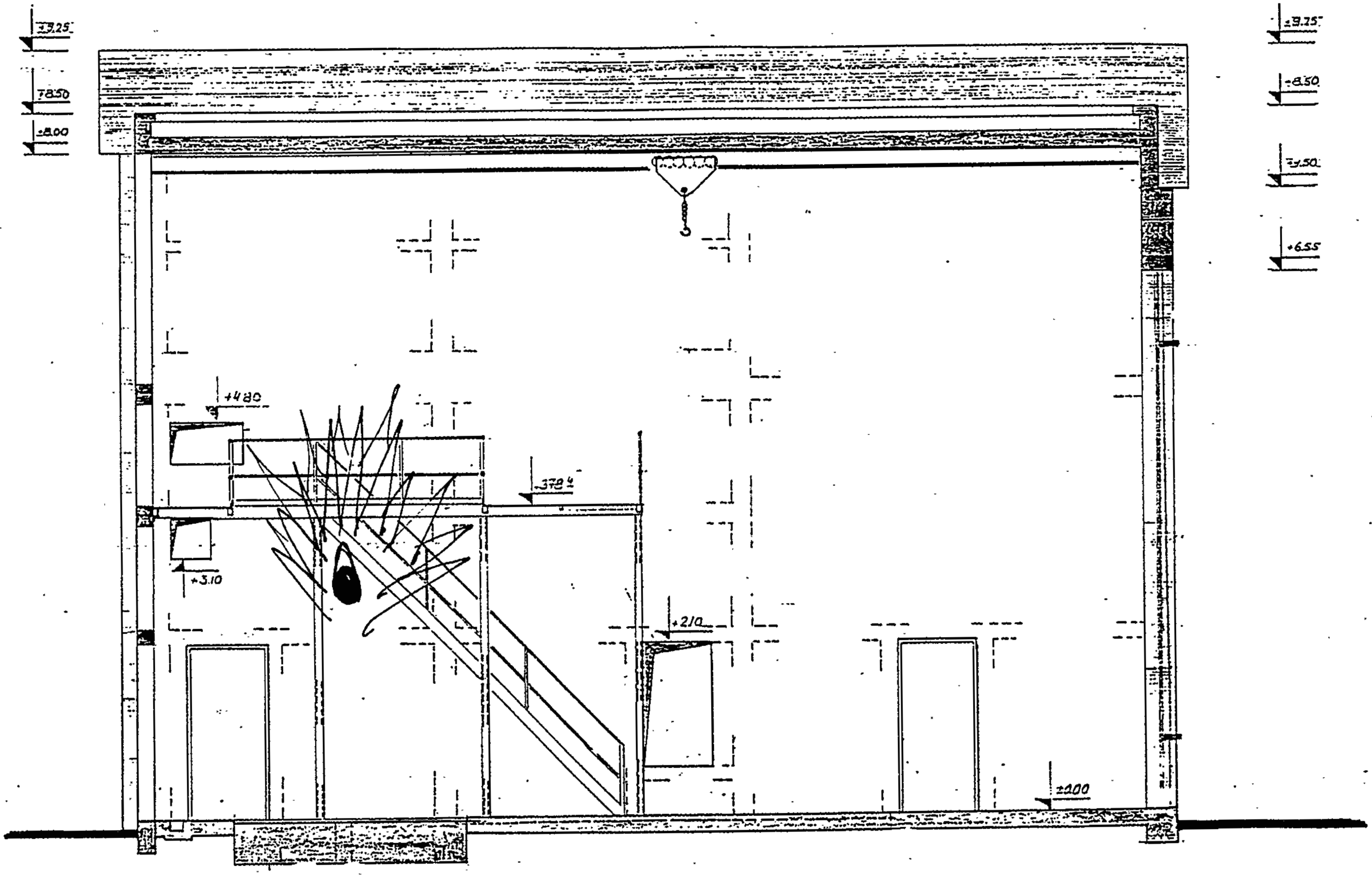


Fig. no' 4 - Longitudinal section of the production hall

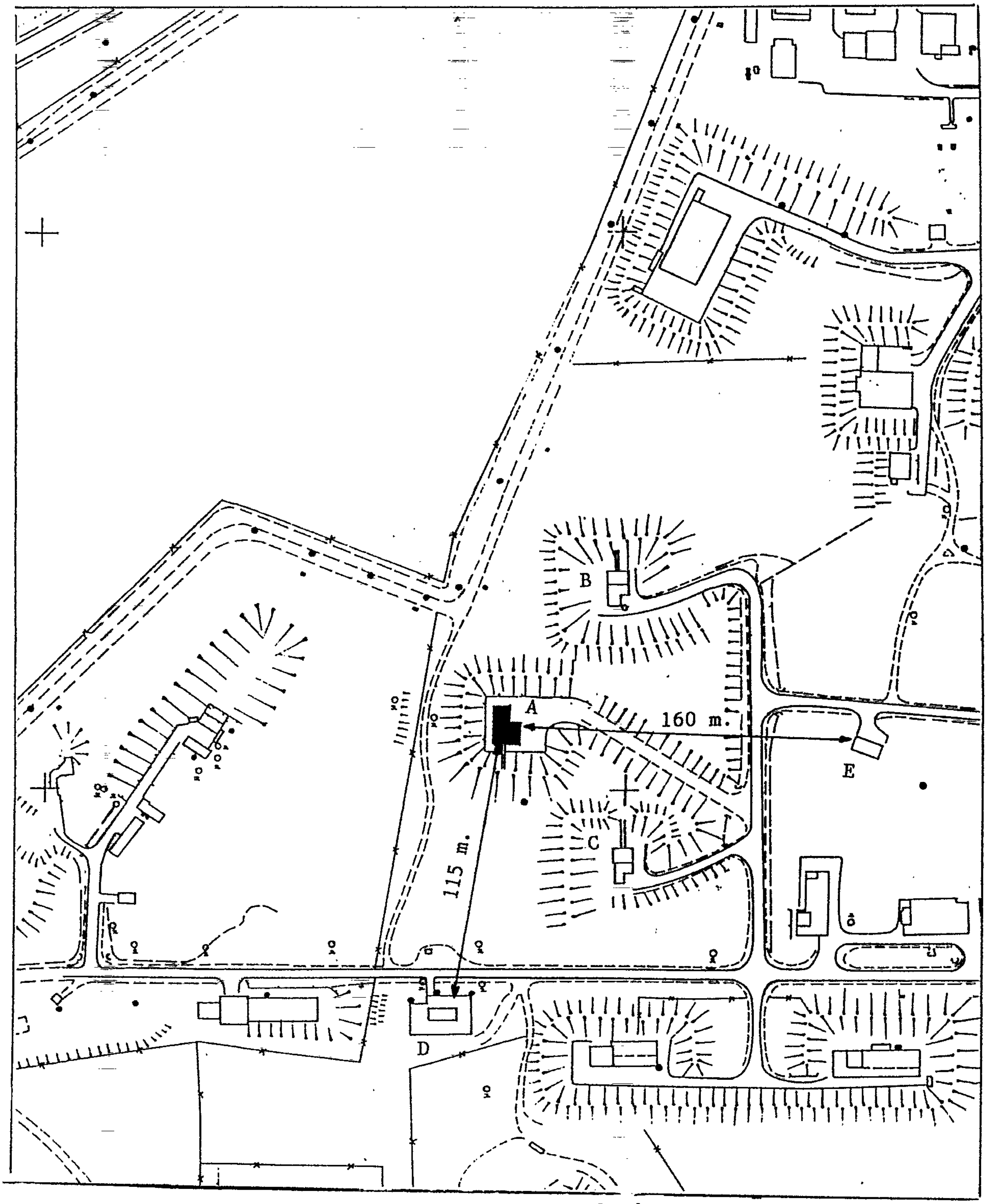


Fig. no' 5 - Map of the area

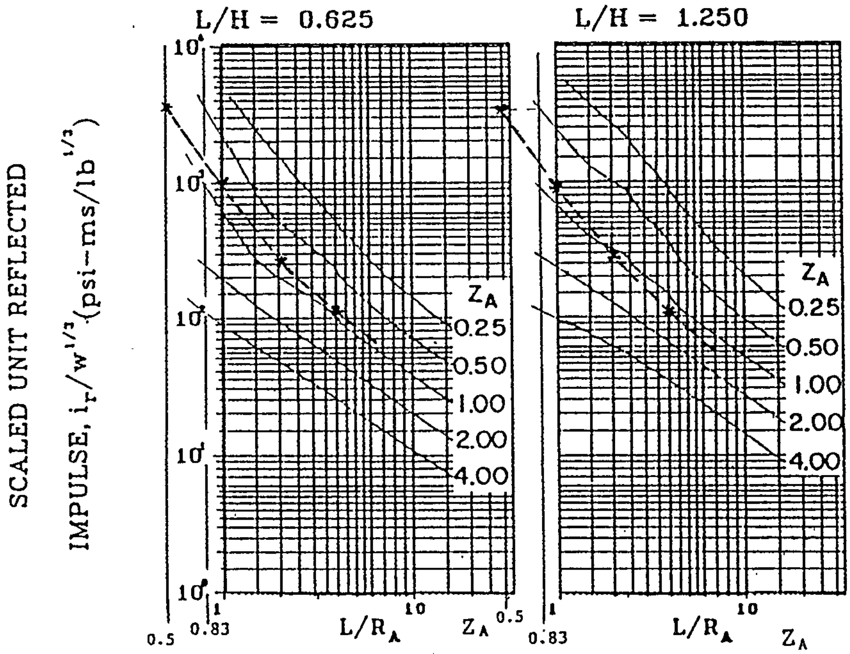


Figure 2-136 Scaled average unit reflected impulse
(6) (N = 3, ℓ/L = 0.25 and 0.75, h/H = 0.50)

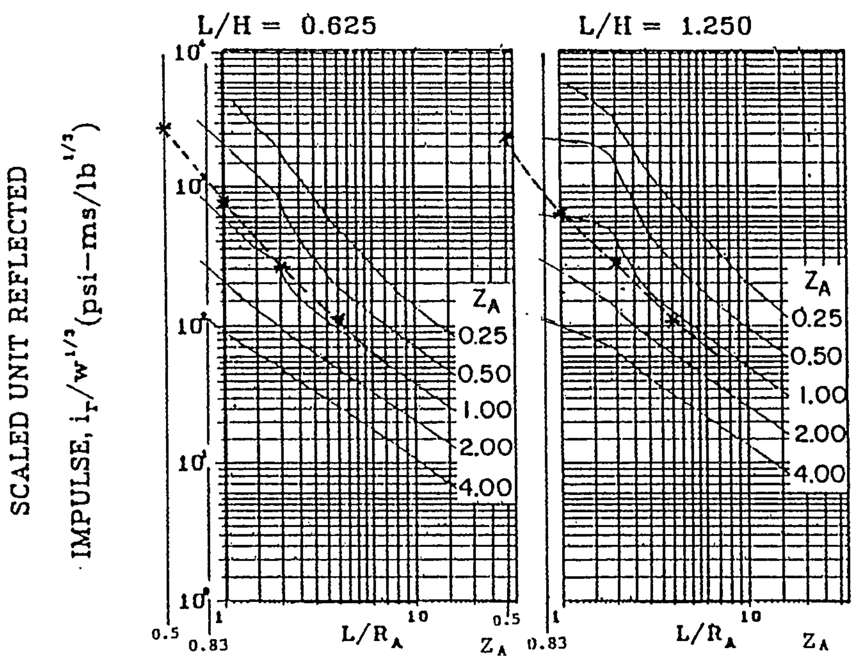


Figure 2-137. Scaled average unit reflected impulse
(7) (N = 3, ℓ/L = 0.50, h/H = 0.50)

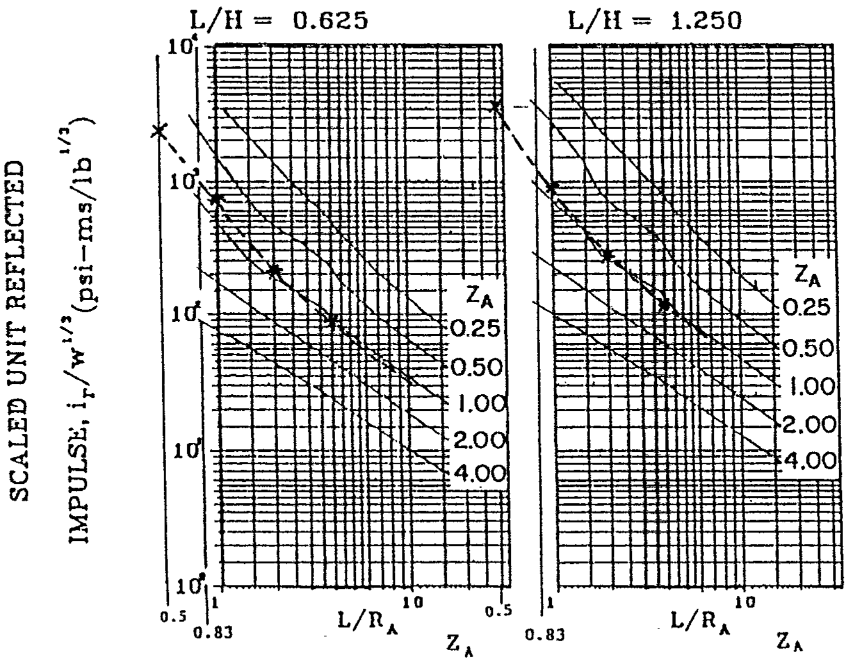


Figure 2-139 (8) Scaled average unit reflected impulse (N = 3, ℓ/L = 0.25 and 0.75, h/H = 0.75)

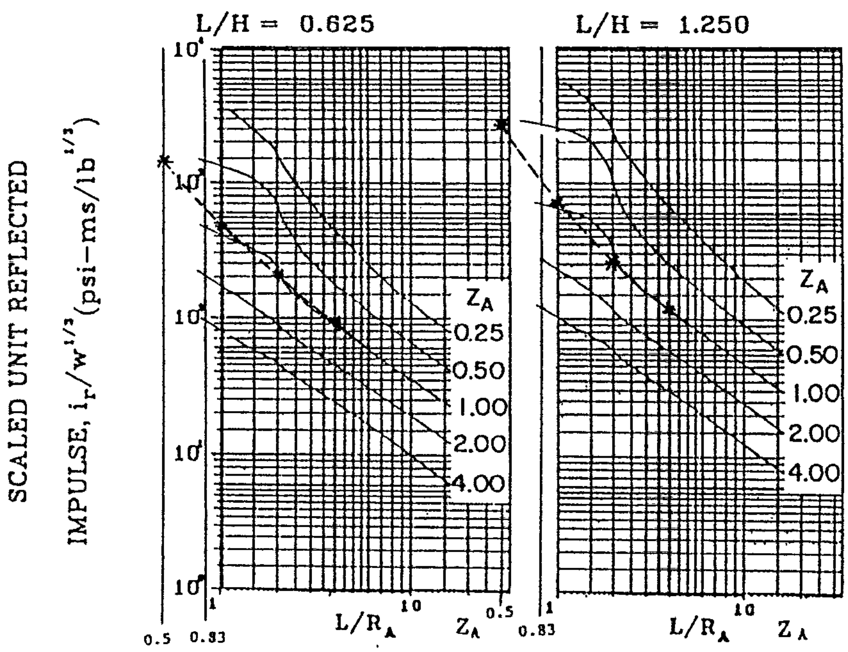


Figure 2-140 (9) Scaled average unit reflected impulse (N = 3, ℓ/L = 0.50, h/H = 0.75)

W kg	W lb	W $^{1/3}$	Z	fig. 2.136 L/H=0.625	fig. 2.136 L/H=1.25	fig. 2.136 L/H=0.83	fig. 2.137 L/H=0.625	fig. 2.137 L/H=1.25	fig. 2.137 L/H=0.83
100	220	6.04	5.22	573	483	543	422	483	442
150	330	6.91	4.56	691	691	691	622	622	622
200	440	7.61	4.14	912	837	887	760	760	760
250	550	8.19	3.84	1064	982	1036	900	900	900
300	660	8.71	3.62	1219	1132	1190	1045	1132	1073
250	770	9.17	3.44	1375	1375	1375	1192	1283	1222
400	880	9.58	3.29	1437	1437	1437	1341	1389	1356
450	990	9.97	3.16	1595	1595	1595	1395	1495	1428
500	1100	10.32	3.05	1754	1754	1754	1551	1651	1584

Table no' 1 - Unit reflected impulse [psi-msec]

W kg	W lb	W $^{1/3}$	Z	fig. 2.139 L/H=0.625	fig. 2.139 L/H=1.25	fig. 2.139 L/H=0.83	fig. 2.140 L/H=0.625	fig. 2.140 L/H=1.25	fig. 2.140 L/H=0.83
100	220	6.04	5.22	422	543	461	404	543	449
150	330	6.91	4.56	552	691	597	453	691	531
200	440	7.61	4.14	646	837	700	608	875	696
250	550	8.19	3.84	737	982	817	737	1064	844
300	660	8.71	3.62	827	1088	913	836	1219	962
350	770	9.17	3.44	962	1192	1037	962	1329	1083
400	880	9.58	3.29	1053	1389	1163	1025	1437	1160
450	990	9.92	3.16	1196	1488	1292	1096	1437	1208
500	1100	10.32	3.05	1341	1599	1426	1240	1651	1343

Table no' 2 - Unit reflected impulse [psi-msec]

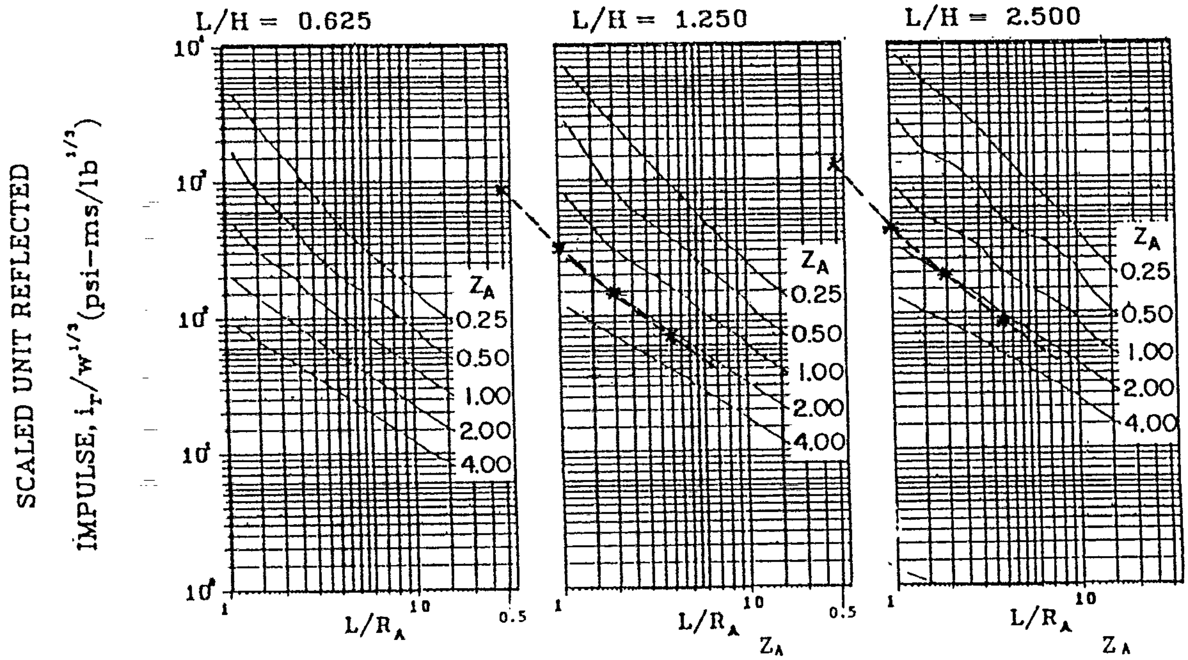


Figure 2-144 Scaled average unit reflected impulse
(10) (N = 4, ℓ/L = 0.10, h/H = 0.25 and 0.75)

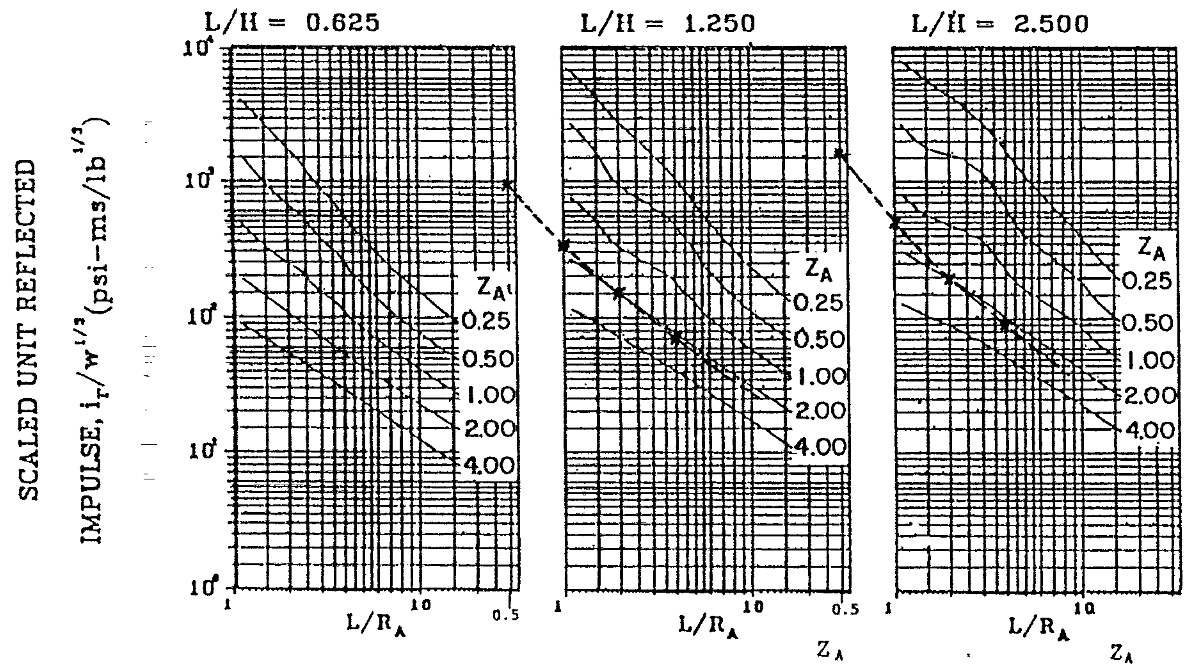


Figure 2-145 Scaled average unit reflected impulse
(11) (N = 4, ℓ/L = 0.25 and 0.75, h/H = 0.25 and 0.75)

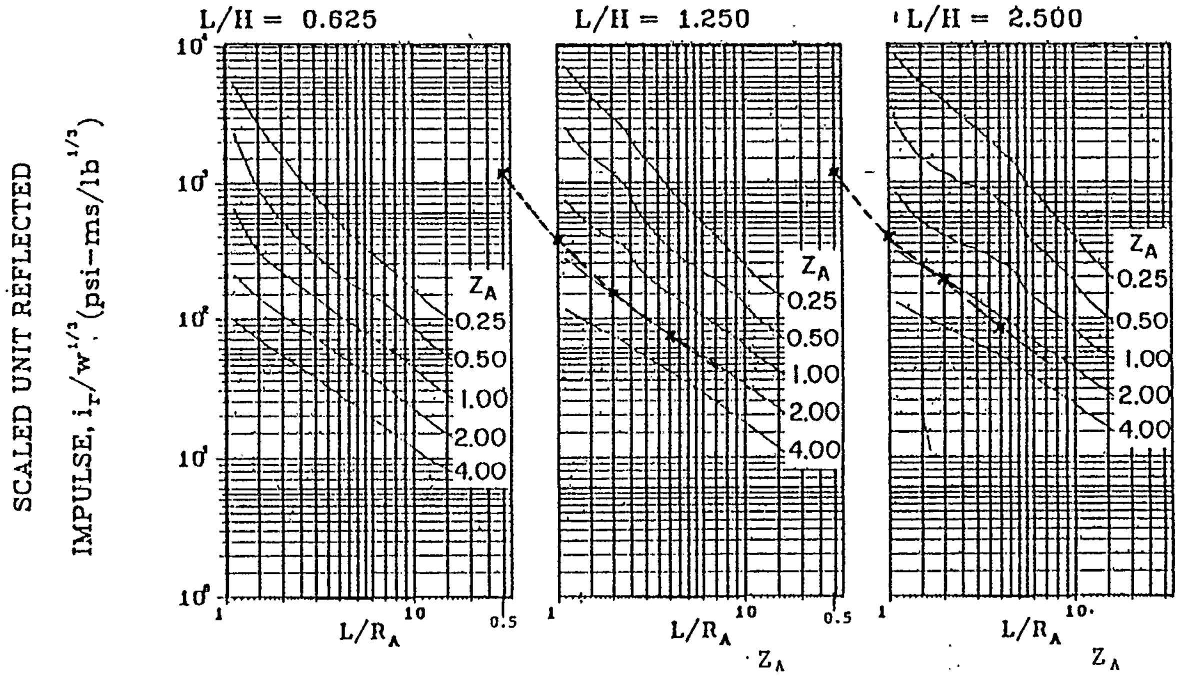


Figure 2-147 Scaled average unit reflected impulse
(12) (N = 4, ℓ/L = 0.10, h/H = 0.50)

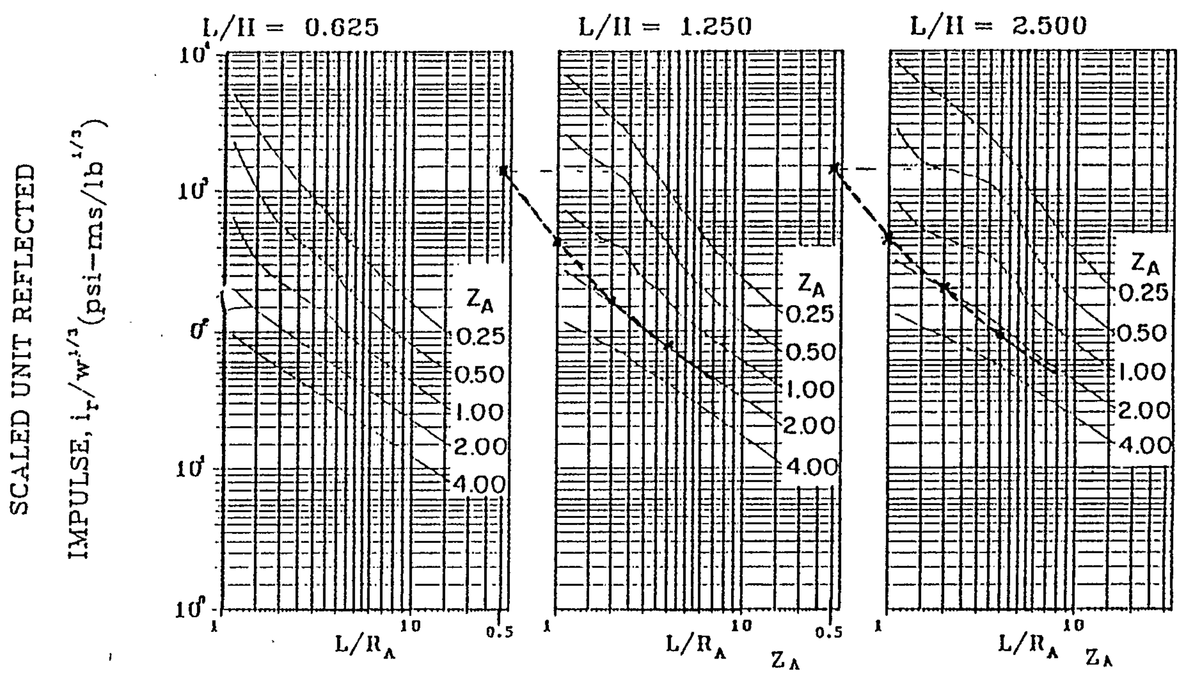


Figure 2-148 Scaled average unit reflected impulse
(13) (N = 4, ℓ/L = 0.25 and 0.75, h/H = 0.50)

				fig. 2.144			fig. 2.145		
W kg	W lb	$W^{1/3}$	Z	L/H=1.25	L/H=2.5	L/H=1.51	L/H=1.25	L/H=2.5	L/H=1.51
100	220	6.04	3.31	513	604	531	513	604	531
150	330	6.91	2.89	691	829	719	691	829	719
200	440	7.61	2.63	837	1065	884	837	1065	884
250	550	8.19	2.44	982	1269	1041	982	1269	1041
300	660	8.71	2.30	1132	1437	1195	1132	1437	1195
350	770	9.17	2.18	1237	1604	1313	1237	1604	1313
400	880	9.58	2.09	1341	1724	1420	1341	1724	1420
450	990	9.97	2.01	1445	1894	1538	1445	1894	1538
500	1100	10.32	1.94	1548	2064	1655	1548	2064	1655

Table no' 3 - Unit reflected impulse [psi-msec]

				fig. 2.147			fig. 2.148		
W kg	W lb	$W^{1/3}$	Z	L/H=1.25	L/H=2.5	L/H=1.51	L/H=1.25	L/H=2.5	L/H=1.51
100	220	6.04	3.31	543	634	561	513	664	544
150	330	6.91	2.89	725	829	746	691	829	719
200	440	7.61	2.63	875	1065	915	800	1027	847
250	550	8.19	2.44	1023	1228	1065	941	1228	1000
300	660	8.71	2.30	1132	1437	1195	1088	1393	1151
350	770	9.17	2.18	1283	1558	1340	1237	1513	1294
400	880	9.58	2.09	1437	1724	1496	1437	1820	1516
450	990	4.97	2.01	1545	1894	1617	1645	2043	1728
500	1100	10.32	1.94	1651	2064	1737	1754	2218	1850

Table no' 4 - Unit reflected impulse [psi-msec]

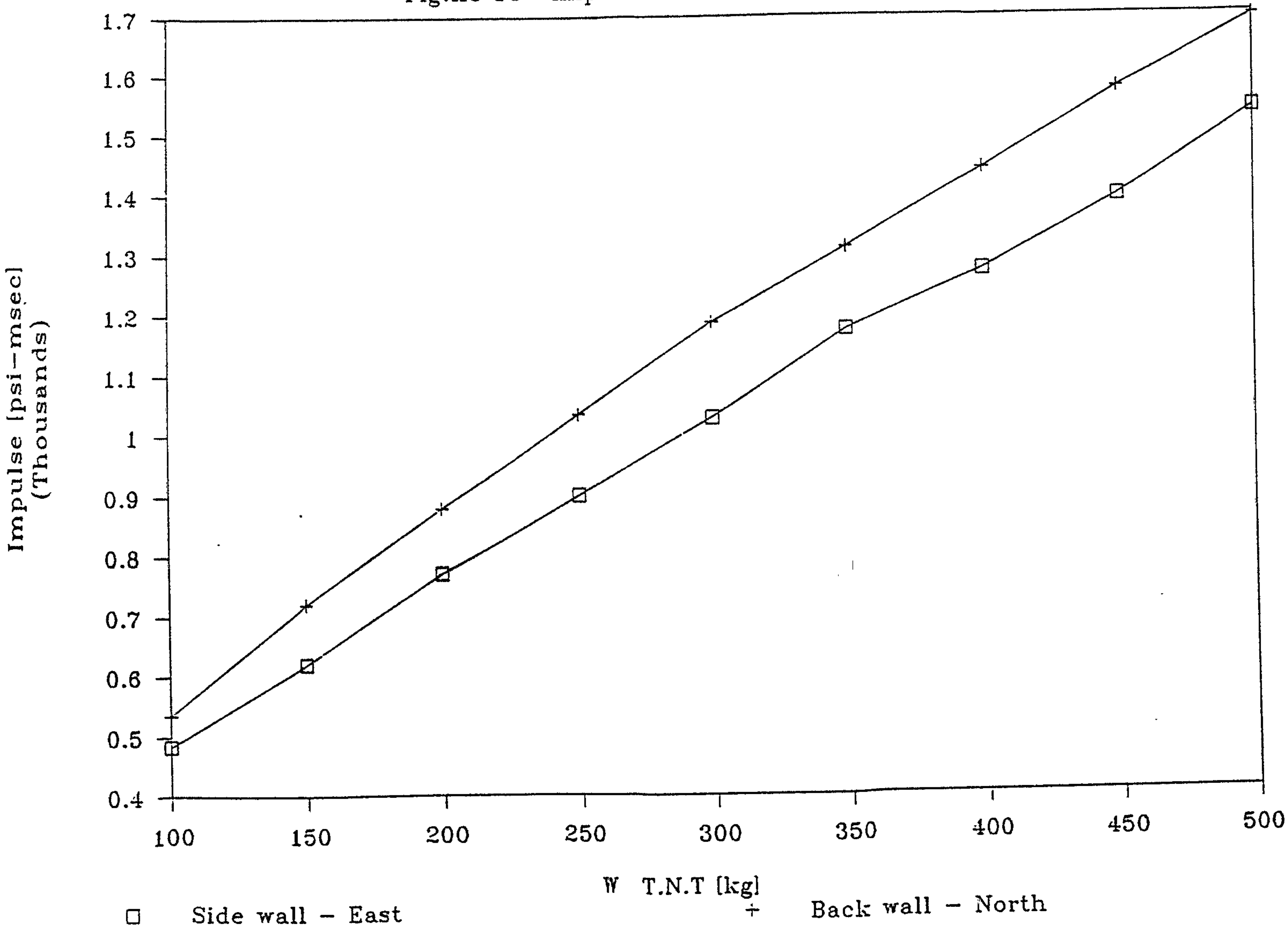
W kg	W lb	fig 2.136 h/H=0.5 1/L=0.25	fig 2.137 h/H=0.5 1/L=0.5	interpolated values h/H=0.5 1/L=0.31	h/H=0.64 1/L=0.31	h/H=0.75 1/L=0.31	fig 2.139 h/H=0.75 1/L=0.25	fig 2.140 h/H=0.75 1/L=0.5
100	220	543	442	517	483	458	461	449
150	330	691	622	673	620	580	597	531
200	440	887	760	855	771	705	700	696
250	550	1036	900	1002	901	823	817	844
300	660	1190	1073	1160	1028	925	913	962
350	770	1375	1222	1336	1174	1048	1037	1083
400	880	1437	1356	1416	1273	1162	1163	1160
450	990	1595	1428	1553	1395	1271	1292	1208
500	1100	1754	1584	1711	1539	1405	1426	1343

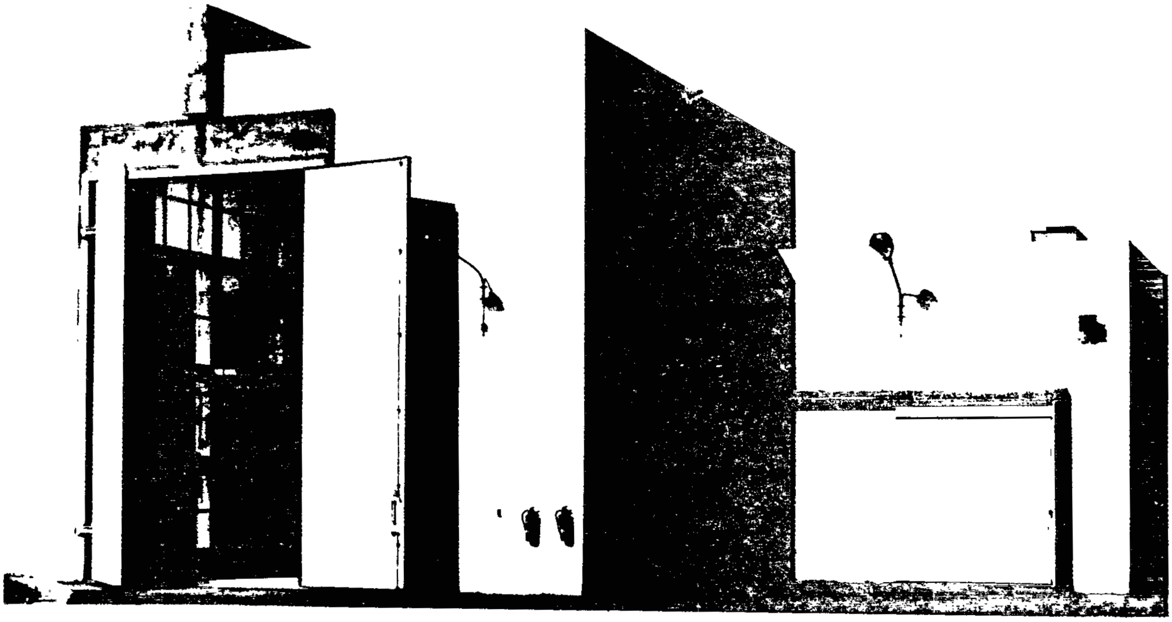
Table no' 5 - Interpolated values of the impulses on the eastern wall [psi-nsec]

W kg	W lb	fig 2.144 h/H=0.25 1/L=0.10	fig 2.145 h/H=0.25 1/L=0.25	interpolated values h/H=0.25 1/L=0.21	h/H=0.31 1/L=0.21	h/H=0.50 1/L=0.21	fig 2.147 h/H=0.50 1/L=0.10	fig 2.148 h/H=0.50 1/L=0.25
100	220	531	531	531	535	548	561	544
150	330	719	719	719	720	726	746	719
200	440	884	884	884	879	866	915	847
250	550	1041	1041	1041	1035	1018	1065	1000
300	660	1195	1195	1195	1187	1163	1195	1151
350	770	1313	1313	1313	1311	1307	1340	1294
400	880	1420	1420	1420	1442	1510	1496	1516
450	990	1538	1538	1538	1575	1695	1617	1728
500	1100	1655	1655	1655	1695	1817	1737	1850

Table no' 6 - Interpolated values of the impulses on the northern wall [psi-nsec]

Fig.no'14- Impulse versuse T.N.T charge



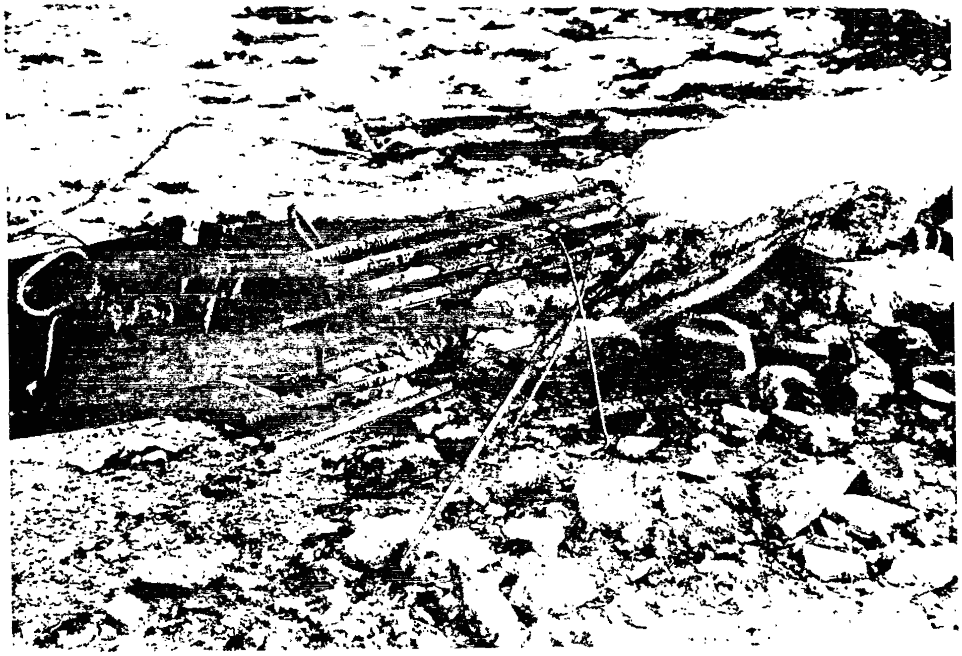


Pic. no' 1 - The building before the accident

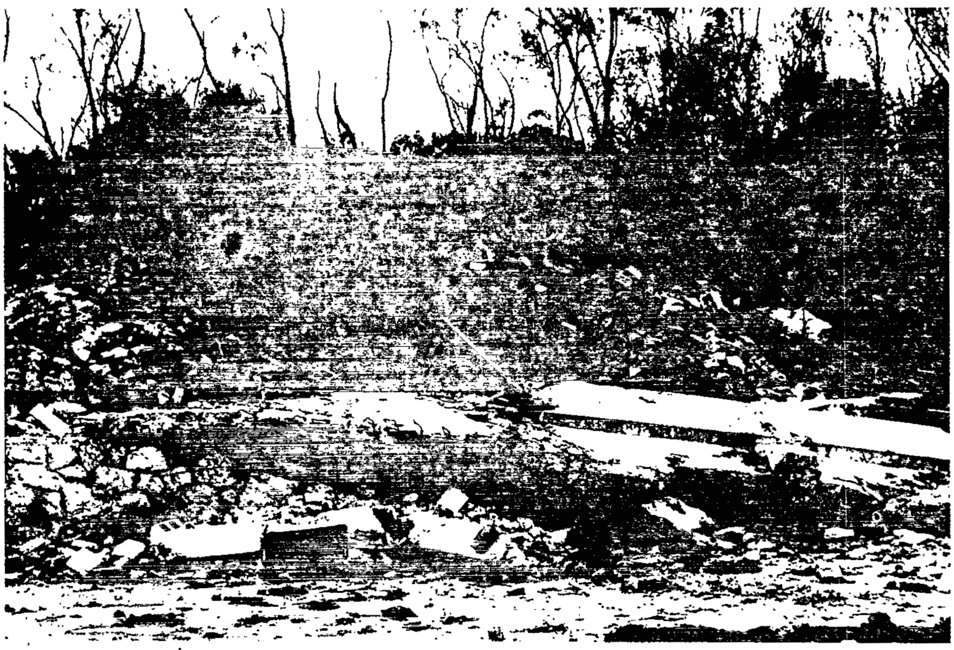
Pic. no' 2 - A view from the eastern barricade

Pic. no' 3 - A view from the
southern barricade

Pic. no' 4 - The light weight wall
of the nearby building



Pic. no' 5 - A broken reinforced concrete column



Pic. no' 6 - A reinforced concrete wall element on the
retaining wall of the barricade edge

Pic. no' 7 - The steel door wing 102 m. from its frame

Pic. no' 8 - The utility room steel door 30 m. from its frame

Pic. no' 9 - Wall blocks beyond the barricade

Pic. no' 10 - The steel door wing on top of
the barricade 70 m. away